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Effect of Replacing Dietary Fish Meal with Silkworm (*Anaphe infracta*) Caterpillar Meal on Performance, Carcass Characteristics and Haematological Parameters of Finishing Broiler Chicken

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Abstract: The effects of substituting fish meal with different levels of silkworm (*Anaphe infracta*) caterpillar meal (SCM) on the growth, carcass characteristics haematology and economics of production formed the basis of this study. A total of one hundred and fifty four weeks old anak broilers were randomly allotted to five treatment groups in a completely randomized design with each treatment having thirty birds. Each treatment group was further divided into two replicates of fifteen birds per replicate. Five diets which had 100% FM: 0% SCM; 75% FM: 25% SCM; 50% FM: 50% SCM; 25% FM: 75% SCM and 0% FM: 100% SCM were formulated and labeled diets 1, 2, 3, 4 and 5, respectively with diet 1 serving as the control. Feed and water were provided *ad-libitum*. The performance in terms of feed intake (95.71g-98.25g), body weight gain (46.10g-98.51g), feed conversion efficiency (1.98-2.08) and protein efficiency ratio (2.41-2.54) showed no significant ($P > 0.05$) differences across the dietary treatments. Analysis of weight of carcass and body cuts as well as blood parameters apart from blood albumin indicated no significant ($P > 0.05$) differences between the treatment means. Cost per kg of feed gradually decline with increasing dietary level of SCM inclusion levels indicating higher economic benefit. The result of this study revealed that the growth performance of the birds was not affected by the incorporation of silkworm caterpillar meal and it was more cost effective than conventional fish meal. It was concluded that cheaper silkworm caterpillar meal can be use as a complete substitute for fish meal in the diet of finishing broiler chickens.

Key words: Animal protein, silkworm caterpillar meal, finishing broiler, fish meal

INTRODUCTION

In most developing countries including Nigeria, animal production is hindered by scarcity and fluctuating quantity and quality of feed ingredients. By the year, 2020, world population is estimated at 8 billion with most of the population growth coming from the developing countries (Singh and Makkar, 2001). This expected surge in population will definitely impact on the animal industry as more animal protein will be demanded. The only hope of supplying the billions with animal protein will depend on the proper exploitation of not only the already known unconventional feed ingredients but also the identification and introduction of new and lesser known plants and animal feed resources which are not in direct competition with human.

Poultry meat contributes approximately 37% of the total animal protein supply in most developing countries and there is the possibility of growth and expansion of this industry (Ahmed and Islam, 1990; Khatun *et al.,* 2003). Broiler (meat type chickens) producers are facing much difficulty with availability and higher prices of feed ingredients (Khatun *et al.,* 2003). Feed ingredients especially animal protein sources are very expensive and scarce due to high competition among poultry, human and other animals resulting in the escalating cost of these ingredients. The cost of feed constitutes the major proportion of between 60-75% of the total cost of poultry production and protein cost account for over 15% of the total feed cost in livestock and poultry farming (Bhuiyan, 1998; Awoniyi *et al.,* 2004; Ojewola *et al.*, 2005). The price of conventional protein feeds resources such as groundnut cake, fish meal and soybean meal, is on the high side and cannot permit profit maximization in poultry ventures. It has also been reported that fish meal is the only conventional animal protein source for poultry and that fish meal is scarce, expensive and most importantly in recent times its quality is questionable (Akpodiete and Inoni, 2000; Etuk *et al.*, 2003; Karimi, 2006). In view of this, current research interest in the poultry industry is aimed at finding alternatives to this elusive feed ingredient. One of such unconventional animal feed ingredient worth considering to replace the scarce, expensive and elusive fish meal is silkworm caterpillar meal.

Silkworm caterpillar is not a worm but the caterpillar of moth butterfly (*Bombyx Mori)* whose cocoon is used to make silk (Anonymous, 2005). Silkworm caterpillar hatches from a tiny black egg laid by the adult moth. It feeds on mulberry and shear butter leaves constantly and grows to full size of 7.5-10cm within 4-6 weeks (Enchanted learning, 2005; SN1, 2005). Silkworm caterpillar meal is of high biological value rich in protein (63.8%:56.8%), lipid (19.6%:31.5%), crude fibre (0%:5.8%) and ash (7.4%:3.3%) (SN1, 2005; Loselevich *et al.,* 2004, respectively). Apart from these food nutrients, it has an amino acid profile which in most cases compares favourably with those of fish meal (Solomon and Yusufu, 2005). Research work on silkworm caterpillar meal as feed ingredient in Nigeria is scanty and hence this study was designed to evaluate the impact of silkworm caterpillar meal on the performance and economics of production of finishing broiler chickens.

MATERIALS AND METHODS

This study was conducted at the Poultry Unit of the Department of Animal production, School of Agriculture and Agricultural Technology Teaching and Research Farm, Federal University of Technology, Minna, Niger State Nigeria. Silkworm caterpillar was collected at the beginning of the rainy season. They were killed by putting in jute sack and dipping in a drum of hot water. The caterpillar were then dried in the sun for 3-5 days and then milled into silkworm caterpillar meal and stored.

Five isocaloric and isonitrogenous diets (20% CP and 3000 kcal/kg) were prepared with silkworm caterpillar meal replacing fish meal at 0% (control), 25, 50, 75 and 100% inclusion levels. They were then labeled diets 1, 2, 3, 4 and 5, respectively (Table 1). A total of one hundred and fifty (5-weeks old) anak broilers were randomly allotted to five dietary treatments of two replicates each. Each treatment had 30 birds of 15 birds per replicate. The birds were given the formulated diets and water *ad-libitum* for a period of four weeks. 60 watt bulb were used to supply light at night through electricity to provide illumination for continuous feeding. The birds were weighed per replicate at the onset of the experiment and the weights recorded to form the initial weights. Routine medications for broilers were carried out. Feed intake was recorded daily while body weight was taken weekly and from the records of feed intake and body weight, feed conversion ratio and protein efficient ratio were calculated. At the end of the 8th week, two birds per replicate were selected and subjected to digestibility trial in a digestibility cage. A 2-day adjustment period was allowed and droppings collected for five days. The droppings were dried, ground and samples collected and stored. Records of feed consumed for the period of digestibility trial were recorded. The test ingredients (FM and SCM), experimental diets and samples of dried droppings were analyzed according to AOAC (1990) standard procedure (Table 2). The amino acids profile of the test ingredients were determined using the method described by Sparkman *et al.* (1958). On the last day of the experimental trial, carcass analysis was carried out. From the analysis, live weight, slaughter weight, dressed weight and weights of body parts and prime cuts were determined. During carcass analysis blood samples were collected and the haematology of the blood samples conducted according to Dacie and Lewis (1984) method. The economics of production was calculated from expenditure on the birds, feed, medication and miscellaneous expenses.

All data were subjected to one way analysis of variance and means were separated by Duncan's multiple range test using a computer software package Statgraphics 2.0 (1987).

RESULTS AND DISCUSSION

The proximate composition of the test ingredients (fish meal and SCM) and experimental diets are presented in Table 2. The value of 50.30% obtained for the SCM used in the study is different from 56.8% and 63.8%, reported by Loselevich *et al.* (2004); SNI (2005), respectively. Also the crude protein value (60.04%) obtained for the fish meal used for this study was lower than that reported by Aduku *et al.* (1991) (63.1%) and Oduguwa *et al.* (2005) (64.5%) though quite higher than that of silkworm caterpillar meal used in this experiment. Given the wide disparity in the crude protein value of SCM and FM used in this study and sited in literature, one would have expected a significant reflection of this in the performance indices of the bird (Table 3) on which this study was based. Feed intake which ranged form 95.71g in diet 5 to 98.52g in diet 4 indicated no significant ($P > 0.05$) differences among the treatment means that could be attributed to silkworm caterpillar meal inclusion. This agrees with the observations of Khatun *et al.* (2003); Loselevich *et al.* (2004); Khatun *et al.* (2005) who reported that SCM has pleasant aroma and is palatable and acceptable by both broilers and laying birds.

Also there was increased growth performance with increasing silkworm caterpillar meal level in the diet up to 75%. The drop in weight at the 100% inclusion level showed no significant ($P > 0.05$) difference from the control. This result agrees with the observations of Rahman *et al.* (1996) and Khatun *et al.* (2003) who attributed the improved growth performance of SCM fed broilers to balanced amino acids profile of SCM.

The efficiency of feed utilization of the birds showed no significant ($P > 0.05$) differences by any level of SCM inclusion indicating that all the diets furnished adequate nutrient for growth as reported by Reddy *et al.* (1991) and Solomon and Yusufu (2005). In the same vain the Protein efficiency ratio (PER) of the birds increase with increasing level of SCM in the diets. Improved protein efficient ratio of broilers on diets with SCM in the current study coincides with the findings of Fadiyimu *et al.* (2003) who reported that the protein requirement of broilers at the finisher phase depends more on the amino acid profile than the total nitrogen content of the

Table 1: Inclusion Levels of Ingredients of Experimental Finisher Diets (%)

	Diets (FM:SCM)				
Ingredients	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:100)
Maize	62.51	62.16	61.80	61.06	60.67
Groundnut cake	20.62	20.88	21.15	21.71	22.00
Fish meal	6.87	5.22	3.53	1.81	0.00
Silkworm caterpillar meal	0.00	1.74	3.53	5.42	7.33
Rice bran	5.00	5.00	5.00	5.00	5.00
Bone meal	4.00	4.00	4.00	4.00	4.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analysis (%)					
Crude protein	20.00	19.97	19.93	20.04	20.00
Crude fibre	16.84	15.76	16.14	17.22	18.21
Ether extract	7.72	5.21	4.84	4.91	3.96
Ash	9.11	10.16	13.25	8.18	8.24
Calcium	2.20	2.11	2.09	1.68	1.72
Phosphorus	1.95	2.12	1.49	1.42	1.47
Metabolizable energy (Kcal/kg)	3020.44	3020.46	3010.49	2996.69	2985.70

*Supplied per kg: Vit A: 7,500iu; D: 500,000iu; E: 1000iu; B_1: 375mg; B_2: 12mg; B_3: 500mg; B_6: 150mg; B_{12}: 25mg; K: 15mg; C: 10mg and Folic acid: 150mg; Ca: 0.25mg; Choline: 250mg; Panthotenic acid: 14.4mg; Lysine, Methonine and terramycin (Broad-spectrum antibiotics and growth promotants).

Table 2: Proximate Composition of Experimental Finisher Diet, Test Ingredients and Nutrient Digestibility

	Diets (FM:SCM)					Test Ingredients	
Components (%)	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:100)	FM	SCM
Dry matter	97.71	93.25	91.69	93.30	92.30	93.74	94.90
Crude protein	21.61	20.94	20.97	20.08	19.48	60.04	50.30
Crude fibre	18.71	16.29	15.92	18.86	18.36	7.63	10.90
Ether extract	8.06	4.22	5.06	4.32	4.35	10.26	16.43
Ash	8.24	11.17	12.91	7.13	7.70	19.80	12.03
Nitrogen free extract	43.38	47.38	45.14	49.63	50.12	2.27	10.34
Calcium	1.91	1.77	1.34	1.82	1.20	4..53	2.77
Phosphorus	1.30	1.22	1.09	1.14	1.02	1.33	1.05
Digestibility (%)						SEM	LOC
Dry matter	81.23	81.65	39.89	79.95	80.63	0.41	NS
Crude protein	83.32	82.83	81.47	80.69	81.89	0.40	NS
Crude fibre	93.38[a]	82.99[d]	85.46[c]	83.67[cd]	88.69[b]	0.83	*
Ether extract	70.29	67.82	70.87	83.67	68.97	0.71	NS
Ash	36.65[c]	49.48[c]	51.90[b]	66.02[a]	22.36[d]	3.15	*
Nitrogen free extract	90.20[c]	92.02[b]	91.97[b]	16.42[c]	94.10[a]	0.20	*

Table 3: Performance of Finishing Broiler Chickens Fed Varying Replacement Levels of Silkworm Caterpillar Meal for Fish Meal

	Diets (FM:SCM)						
Component	1 (100:0)	2 (75:25)	3 (50:50)	4 (25:75)	5 (0:100)	SEM	LOS
Initial weight (g)	581.84	573.37	592.12	550.70	532.12	5.12	NS
Final weight (g)	1940.00	1935.00	1887.50	1890.00	1885.00	12.36	NS
Average daily feed intake (g)	97.45	97.93	98.27	98.52	95.71	4.70	NS
Average daily weight gain (g)	49.19	49.29	49.38	49.51	46.10	2.19	NS
Feed conversion ratio	1.98	1.99	1.99	1.99	2.08	0.03	NS
Protein efficiency ratio	2.41	2.51	2.52	2.52	2.54	1.03	NS
Cost analysis Cost of feed (N/kg)	34.62	33.84	32.88	29.43	27.37		
Cost of daily intake (N/g)	3.41	3.32	3.14	2.86	2.58		
Cost/kg of gain	69.32	67.36	63.59	57.77	55.97		

SEM: Standard error of the means; LOS: Least significant difference; NS: Not significant.

Table 4: Effect of Varying Replacement Levels of Silkworm Caterpillar Meal for Fish Meal on Carcass Characteristics and Haematological parameters of Finishing Broiler Chickens

	Diets (FM:SCM						
Parameters	1 (100:0)	1 (75:25)	1 (50:50)	1 (25:75)	1 (0:100)	SEM	LOS
Carcass parameters Live weight (g)	1940.00	1935.00	1887.50	1980.00	1885.00	10.21	NS
Slaughter weight (g)	1860.00	1870.00	1818.00	1825.00	1785.5	6.88	NS
Dress percentage (%)	79.79	76.86	78.09	29.55	74.08	4.95	NS
Viscera(%)	29.16	21.27	21.92	20.67	21.07	1.34	NS
Head (%)	1.93	1.74	2.12	1.71	1.89	0.08	NS
Wing (%)	10.54	9.97	11.31	10.99	9.76	0.37	NS
Breast (%)	11.19	11.37	12.66	11.51	12.06	0.52	NS
Back (%)	10.56	9.56	10.60	10.61	10.11	0.42	NS
Gizzard (%)	2.32	1.94	2.39	2.01	2.05	0.09	NS
Lungs (%)	0.70	0.60	0.74	0.69	0.68	0.04	NS
Heart (%)	0.57	0.44	0.45	0.51	0.54	0.02	NS
Liver (%)	1.75	1.55	1.75	1.62	1.70	0.07	NS
Kidney (%)	0.06	0.52	0.59	0.50	0.57	0.04	NS
Haematological parameters							
Blood Sugar (mg/dl)	12.90	12.33	1295	12.25	11.98	0.14	NS
Total protein (mg/dl)	4.30	3.39	3.85	3.85	3.80	0.09	NS
Cholesterol (mg/dl)	2.68	2.73	2.78	2.98	2.53	0.10	NS
Globulin (mg/dl)	2.15	2.29	2.38	1.95	1.88	0.08	NS
Albumin (mg/dl)	1.56^{a}	1.28^{b}	1.43^{ab}	1.45^{ab}	1.29^{a}	0.04	*
MCHC(%)	33.24	31.41	32.27	32.89	31.16	0.38	NS
Mean corpuscular volume %	115.10	118.00	120.89	116.01	113.75	2.42	NS
Mean corpuscular haemoglobin (%)	20.78	19.85	20.33	19.53	20.03	0.18	NS
Packed cell volume (%)	31.48	31.47	31.49	31.15	31.67	0.20	NS
White blood cell (103/mm^3)	8.90	9.39	9.15	9.72	10.27	0.25	NS
Red blood cell (106/mm^3)	2.85	2.46	2.64	2.98	2.67	0.09	NS
Haemoglobin (g/dl)	10.53	10.53	10.39	10.12	10.13	0.19	NS

MCHC: Mean corpuscular haemoglobin concentration.

Table 5: Amino Acids (gN/100g Protein) profile of Experimental Fish Meal and Silkworm Caterpillar Meal

	Lysine	Histidine	Arginine	Aspartic acid	Threonine	Serine	Glutamic acid	Proline
Fish meal	4.56	2.45	5.01	7.02	2.15	3.15	11.06	2.09
SCM	5.02	3.00	4.50	9.31	2.81	4.65	13.90	2.35

Table 5: Continue

Amino acid	Glycine	Alanine	Cysteine	Valine	Methionine	Isoleucine	Leucine	Tyrosine	Phenylalanine
Fish meal	4.03	2.69	1.09	3.02	2.20	3.01	6.90	2.89	3.45
SCM	4.10	4.46	1.56	3.68	3.02	3.32	7.25	3.41	4.11

protein source. It is observed from the amino acid profile of the test ingredient (SCM) used in this study furnishes more essential amino than the corresponding FM which invariably informed the observed performance.

Crude protein digestibility was highest in diet 1 (100% FM). This result was expected because of the low fibre and fat content of fish meal which encouraged digestibility. This result is in line with the report of Deshmukh and Pathak (1991) who showed that the intake of crude protein, its digestibility and total digestible nutrient was highest at high protein level and lowest at low protein level.

The result of carcass analysis showed no significant (P. 0.05) differences among the treatment means. This result agreed with the findings of Aduku *et al.* (1991) and Ijaiya and Fasanya (1999) who opined that the average dressing percentage and weights of the carcass parameters of rabbits fed different levels of protein and energy are similar as well as the result of Kumur *et al.* (1992) who reported that the dressed weight of broilers increased almost linearly on increasing dietary levels of silkworm pupae meal and that sex had little effect on any meat yield characteristics.

The analysis of blood parameters apart form blood albumin showed no significant ($P > 0.05$) differences among the dietary treatment means and the result of this analysis are within the normal ranges for normal chickens reported by Anon (1980). However the significant ($P < 0.05$) difference observed in the blood albumin could be due to the protein composition of silkworm caterpillar meal and its utilization as reported by Nandeesh *et al.* (1998) and Tona *et al.* (2006).

Progressive decrease in the cost of production per unit of feed intake and gain in weight with increasing level of

SCM inclusion in the diet as shown in Table 3 agreed with the report of Atteh and Ologbenla (1993), Khatun *et al.* (2003) and Khatun *et al.* (2005). The high cost of feed per daily gain observed in diet 1 with 100% fish meal is in line with the report by many authors that fish meal is scarce, expensive and result in high cost of production when included as the only animal protein source in broiler diets (Oduguwa *et al.*, 2005; Ojewola *et al.*, 2005 and Karimi, 2006).

Conclusion: This study clearly shows that SCM can completely and effectively replace FM without adverse effect on the performance, carcass characteristics and haematological parameters of finishing broilers and it is more cost effective. It is however recommended that more research be conducted to assess the effect of processing such as defattening and other drying methods on nutrient quality and the inherent effect on broiler performance.

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